

THE BIOLOGY AND IMMATURE STAGES OF *ZYGOGRAMMA SUTURALIS* (FABRICIUS) (COLEOPTERA: CHRYSOMELIDAE)^{1, 2}

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The life history of *Zygogramma suturalis* (Fabricius), a bivoltine species associated with the ragweeds, *Ambrosia* spp., was studied in Northeastern Ohio during 1969 and 1970. Overwintered adults became active and began feeding in early May. Eggs were laid in clusters of two or three on the undersides of young leaves. Recently hatched larvae fed gregariously on the same leaf on which the eggs had been laid. However, second, third, and fourth instars were less gregarious and dispersed randomly to new leaves when the initial food supply was exhausted. Pupation occurred in the soil beneath the host plant. The mean duration of the developmental stages (in days) was: egg 5, larval 15-18, prepupal 7-8, pupal 6-9. Descriptions of the egg, four larval instars, and pupa are presented for the first time.

Each species of weed has its own insect population, just as each economic plant has an associated complex of insects, including pest species, which may reduce the yield or commercial value of the plant. Unlike the economically beneficial plants, many important weeds have been studied poorly regarding the insects utilizing them as hosts. A plant pest in this category is common ragweed, *Ambrosia artemisiifolia* L. (Compositae). In addition to being a serious agricultural weed, it is well-known as an aeroallergenic pollen-producer responsible for summer and fall hayfever throughout much of the United States.

In Northeastern Ohio, the common ragweed supports a diverse assemblage

of phytophagous insects. Between 1968 and 1970, the biology of several coleopterous associates were thoroughly investigated both in the field and laboratory, and the results of a study on a foliage feeding member of this beetle complex *Zygogramma suturalis* is reported.

The genus *Zygogramma* Chevrolat (Chrysomelidae: Chrysomelinae) is represented by 99 species in the Nearctic and Neotropical regions (Bechyne, 1952). In the United States, there are 14 widely distributed species (Arnett, 1968). Aside from adult taxonomic descriptions and local-faunistic studies, literature on the genus is sparse, probably because of the lack of knowledge on larval feeding habits of most of the essentially non-economic species. Brisley (1925) reported on the larval feeding behavior of *Z. exclamationis* (Fabricius) on sunflower, *Helianthus petiolaris* Nuttall. Douglass (1929) collected the beetle from *H. lenticularis* Rydberg as well as *H. petiolaris*. Walker (1936) presented detailed life history information on *Z. exclamationis* and noted its occurrence on *H. annuus* L. in Kansas. According to Blatchley (1910), adults of *Z. suturalis* (Fabricius) were found on ragweed in low, moist places during the spring and on goldenrod flowers, *Solidago* spp., in the fall. Douglass (1929) collected *Z. suturalis* from weeds in July and August and provided distributional and seasonal information for five additional *Zygogramma* species. Hughes (1939, 1944) found *Z. suturalis* larvae feeding on the leaves of *Ambrosia* spp. and recorded the beetle from 27 Ohio counties.

MATERIALS AND METHODS

Observations on the biology of *Zygogramma suturalis* were made in 1969 and 1970 in Northeastern Ohio, primarily in Portage County within a three-mile radius of Kent. Adults either were swept from the host plants with a standard aerial insect net or were collected in-

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dividually in small vials. Eggs were found by examining the lower surfaces of young ragweed leaves. Entire leaves infested with *Z. suturalis* larvae were clipped from plants, placed in large plastic petri dishes, and transported to the laboratory for further study. Prepupae and pupae were obtained by searching the soil beneath the host plants.

Rearings were maintained in the laboratory at room temperatures of 20°–25°C, 50%–60% RH, and a 12/12 hr photoperiod. Adults were confined to baby food jars (9 x 6 cm) which had their bottoms removed. The jars were inverted and the top of each was pressed into the bottom of a small plastic petri dish (5.5 x 1.3 cm) containing moist peat moss. The open bottom of the jar was covered with a layer of fine mesh nylon netting. Entire ragweed plants, ranging from 8–10 cm in height, were placed in the rearing jars to serve as food and oviposition material, with new plants and water added periodically. As eggs appeared, they were transferred to small petri dishes containing moistened filter paper discs. Larvae were reared individually in petri dishes and were supplied with fresh leaves at 48-hour intervals. Pupae were held in petri dishes containing moist peat moss.

Samples of the developmental stages were preserved. Eggs were preserved in KAAD and studied directly in the preservative. Larvae and pupae were killed in hot water, then preserved in 70% alcohol. For study of gross morphological structures of larvae and pupae, the specimens were removed from the alcohol and placed in water. Minute morphological structures of the larvae such as head capsules, mandibles, and spiracles were dissected out and studied in temporary glycerine mounts. Measurements of the immature stages were made with an ocular micrometer. The ocular grid method, described by Steyskal (1950), was used in making the drawings.

LIFE HISTORY

Zygogramma suturalis has been recorded from Maine, south to Mississippi, and west to Arizona. Adults are broadly oval, convex, and dark brown, usually with a faint bronze or greenish luster; each elytron with base, lateral margin, interval between second and third striae (sometimes also interval between fourth and fifth striae) and basal part of epipleura a pale yellow.

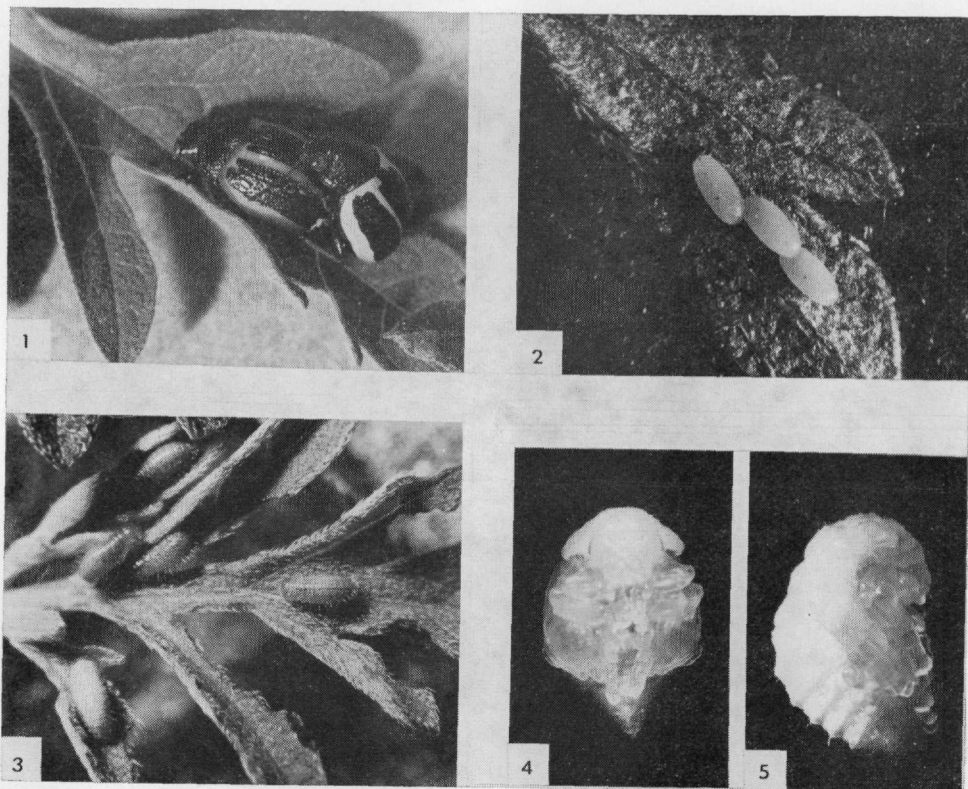
Hughes (1944) gave the earliest and latest Ohio seasonal records for this species as April 14 and September 24. In the Kent area however, the adults were taken from May 4 to September 30. Adults began to emerge when ragweed seedlings were only 2–5 cm tall. Adult populations remained large throughout June, July, and August, but declined steadily during September.

There were two generations per year in Northeastern Ohio. Larvae of the first or spring generation began feeding in mid-May or early June and most reached maturity by early July. Larvae of the second or late summer generation were evident during the first two weeks of August. The adults overwintered in soil or under debris.

Laboratory reared adults lived about two months, with the females generally outliving the males. Adults of both generations fed ravenously upon leaves of the plant, but second generation adults were observed feeding upon the involucre of the pistillate flowers. If approached or disturbed while on the plant, the beetles fell to the ground and feigned death.

No complex courtship behavioral pattern was observed in *Z. suturalis*. The male mounted the female from behind by moving directly forward and onto her dorsum. The forelegs rested upon the female's elytra, while the tarsal claws of the middle pair of legs grasped the elytral margins (fig. 1). The hindtarsi were rubbed rapidly in a sideways fashion across the female's last abdominal sternite preparatory to copulation. After several of these sequential rubbing movements, the aedeagus was extruded and intromission occurred. The female generally remained quite passive during copulation. Copulation lasted from five minutes to well over an hour, and frequently copulation occurred several times during a two to three hour period. Mating was seen most commonly during the late morning and early evening in nature, but it was initiated at various times during the day in the rearing jars.

The preoviposition period was not determined. Daily egg production ranged from 0–37 per female, with the average of 13 per day. Total egg production per female ranged from 145–563, the average being 165. The length of the oviposition period varied from 22–42 days with an average length of 33 days. Eggs were deposited in clusters of two or three on the underside of young ragweed leaves usually near the leaf tip (fig. 2). Occasionally, eggs were laid on the upper surface of leaves. Eggs were anchored firmly to the substrate by a clear mucilaginous secretion and projected out from



FIGURES 1-5. *Zygogramma suturalis*. 1. Mating position of adults; 2. Egg arrangement on leaf underside; 3. First and second instar feeding position and damage; 4. Pupa, ventral view; 5. Pupa, lateral view.

the leaf at about a 45° angle. They were found from the middle of May to late August. The incubation period of eggs held under laboratory conditions was five days. Viability of laboratory-laid eggs exceeded 98%.

Within the eggs, the first instars initiated a series of contractile movements which succeeded in rupturing the chorion in two places. Emergence occurred through these slits and the complete process lasted 15-20 min. Recently hatched larvae actively fed in groups of from two to four on the undersides of leaves, most commonly on the young, succulent, unfolding leaves below the terminal bud. Second, third, and fourth instars tended to be less gregarious in their feeding habits, and often the larvae on any one leaf represented several different instars (fig. 3). Older larvae began to disperse randomly when the initial food supply was exhausted. When feed-

ing, the larvae resembled small spheres or pellets and concealed themselves in leaf folds. When exceedingly abundant, the mature larvae inflicted substantial damage and often completely defoliated portions of a plant, but such instances were observed infrequently in the field. If molested while feeding, third and fourth instars simultaneously regurgitated undigested foodstuffs, which rapidly engulfed the head, and ejected from the anus a comparatively large quantity of dark brown fluid. Eisner and Meinwald (1966) proposed that such exudates presumably produce an offensive odor or taste, causing predators to desist from further attack. Possession of such a behavioral mechanism has considerable survival value for the leaf-feeding larvae. No parasitism of or predation on the immature stages was recorded in the field during the study, but this does not preclude the possibility of its existence. The

first larval stadium was completed in four or five days, the second in three or four days, the third in three or four days, and the fourth in four or five days. Duration of the larval period ranged from 15–18 days.

A fourth instar ceased feeding toward the end of its larval development. The larva became positively geotactic and descended to the ground, whereupon it burrowed 2–8 cm into the soil. Having reached a suitable depth, the larva pushed and compacted the surrounding soil until an oval chamber was formed. The pupal cell was rough externally and smooth inside. The prepupal stage began immediately after the formation of the earthen cell. The fourth instar transformed into a prepupa without molting. It became more rigid and globular in shape but retained all the morphological features of the larva. The prepupal stage lasted seven to eight days, i.e. from the time of chamber formation to the molt into the pupa.

The pupal periods of 148 individuals lasted six to nine days, with most pupae producing adults in seven days. After ecdysis, the teneral adult remained underground for two or three days. It then escaped from the pupal cell by burrowing upward thru the soil. Upon emergence, the adult was lighter in color than normal and quite soft. Within six to eight hours after emergence, the beetles were fully pigmented and sclerotized.

DESCRIPTIONS OF IMMATURE STAGES

Egg (fig. 11). Length 1.45–1.65 mm, maximum width 0.56–0.66 mm. Subshining, yellowish-orange. Oblong-oval, slightly tapered toward the ends, ends bluntly rounded. Chorion asperate, sculptured into raised reticulations forming numerous hexagonal cells, sculpturing uniform throughout. Micropyle located terminally.

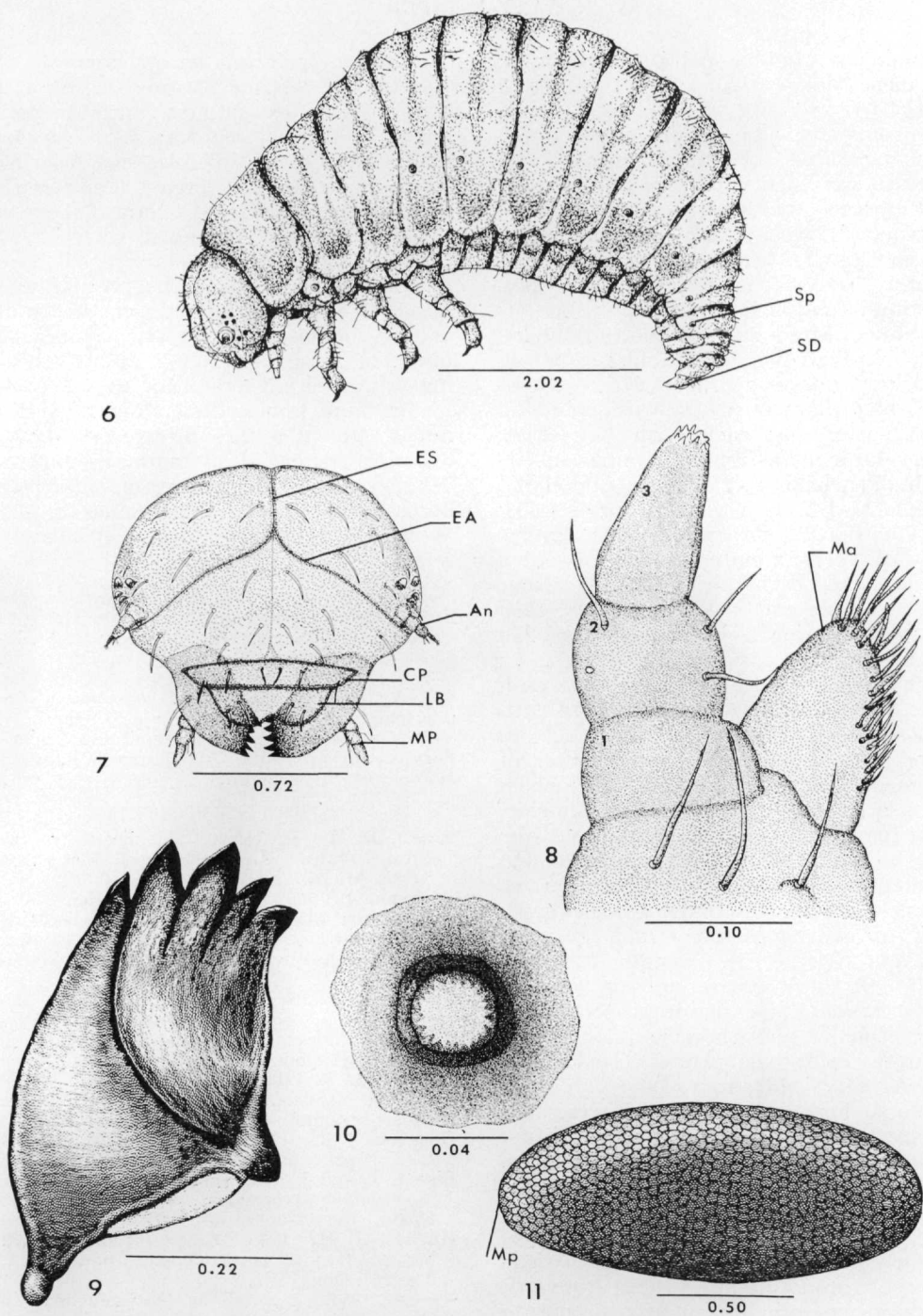
First Instar. Similar to fourth instar except in following characters. Length 1.45–1.91 mm, head width 0.53–0.59 mm. Color pale orange. Form slightly cyphosomatic, somewhat fusiform. All cephalic, thoracic, and abdominal setae longer than those of third and fourth instars; all setae arising from distinct tuberculate bases. Antennal segment 3 longer than

1 or 2. Pronotum weakly sclerotized; not distinct; all setae confined to anterior, posterior, and lateral margins. Pro- and postdorsal folds of thoracic and abdominal segments not distinct; sucking disc extremely protuberant. Spiracles uniform in size, except mesothoracic which are larger.

Second Instar. Similar to first instar except in following characters. Length 2.10–2.97 mm, head width 0.66–0.76 mm. Color pale yellow-orange.

Third Instar. Similar to fourth instar except in following characters. Length 3.30–4.62 mm, head width 0.99–1.12 mm.

Fourth Instar (fig. 6). Length 4.90–6.27 mm, head width 1.32–1.54 mm. Pale yellow, shining; integument thin; sparsely clothed with fine white setae. Form cyphosomatic; sides curved, narrowed anteriorly from abdominal segment 1 and posteriorly from segment 6. Head exserted, hypognathous; head capsule golden yellow, rounded and somewhat shining. Distinct V-shaped epicranial suture (fig. 7); epicranial arms curving ventral to lateral ocelli, ending just posterior to antennal sockets. Frons with 10 setae, 2 just ventral to juncture of frontal suture and coronal suture, 4 in a semi-circular row ventral to those, and 4 widely spaced setae in a row dorsad clypeus. Antennae prominent; 3-segmented; segments 1 and 2 equal in length, 2 with a supplementary process, 3 shortest and tapered. Twelve lateral ocelli; a mid-lateral group of 8 (4 on each side of head), and a ventral pair on each gena. Lenses raised and clear with black pigment bodies beneath. Genae sparsely setose. Distinct fronto-clypeal and clypeal-labral sutures present; clypeus 5–6 times longer than wide with 6 well developed setae. Labrum 4 times longer than wide with a deep mid-ventral incision; 4 setae, 2 on each side of incision; anterior margin beset with 8–10 bristly setae. Mandibles (fig. 9) palmate with 5 distal teeth; teeth reddish-brown, darker than rest of mandible; ectal surface bearing 2 setae. Maxillary palpi (fig. 8) 3-segmented; segment 3 longer than 1 or 2, 1 shortest. Ventral surface of segment 2 with 1 sensillum placodeum; tip of segment 3 invested with 14–15 sensilla basiconica. Mala well developed,



FIGURES 6-11. *Zygogramma suturalis*. 6. Lateral habitus of fourth instar; 7. Head capsule of fourth instar, frontal view; 8. Right maxilla of fourth instar, ventral view; 9. Right mandible of fourth instar, ental view; 10. Abdominal spiracle of fourth instar; 11. Egg. All measurements indicated by scale lines are in millimeters. An, antenna; CP, clypeus; EA, epicranial arm; ES, epicranial suture; LB, labrum; Ma, mala; Mp, micropyle; MP, maxillary palpus; SD, sucking disc; Sp, spiracle.

prominent. Labial palpi 2-segmented; segment 2 longer than 1; tip of segment 2 with 6-7 sensilla basiconica. Ligula, mentum, and submentum setose; hypostoma glabrous. Prothorax, mesothorax, metathorax each with pair of legs; legs 4-segmented, terminating in sclerotized tarsunguli; legs setose ventrolaterally. Pronotum weakly asperate, shining; moderately setose. Prosternum with presternum and eusternum protuberant; glabrous. Meso- and metanotum divided into pro- and postdorsal folds; each fold bearing transverse row of setae. Meso- and metathoracic pleura with epimeron and eusternum; each with 3-4 setae. Meso- and metasternum shining; eusternum of each sparsely setose. Abdominal segments 1-7 each with 2 dorsal folds; pro- and postdorsal folds with transverse row of 12-14 minute setae; group of 3 setae dorsad each spiracle; subspiracular tubercles present on segments 1-8, each tubercle bearing 3-4 setae. Sterna 2-9 with marginal transverse row of fine setae; each sternite with 2 "prolegs", 1 on each side of meson. Segment 9 tapered with 12 scattered long setae. Segment 10 short; 10-12 scattered setae; venter of segment with 2 fused anal prolegs which form a sucking disc. Spiracles annular; peritremes black, heavily sclerotized (fig. 10). Paired spiracles on mesothorax and abdominal segments 1-8; mesothoracic spiracle largest; abdominal spiracles gradually decreasing in diameter posteriorly.

Pupa (figs. 4, 5). Length 4.20-5.04 mm. Body closely resembling form of adult in size, shape, and in proportions of the cephalic and thoracic appendages; exarate; color pale yellow. Head with vertex not visible from above; group of 12 setae dorsad each ocellus; 2 setae near each antennal socket. Clypeo-labrum bluntly triangular; labrum with 2 setae. Antennae arising laterad ocelli, curved and directed posterolaterally, terminating alongside the mid-femora. Eyes slightly convex, glabrous. Lateral margins of pronotum projecting forward; posterior margin bisinuous; pronotum with a shallow, median, longitudinal groove; densely setose. Mesonotum smooth, glabrous; scutellum protuberant with 6 setae; anterior margin of mesopleuron with a large, oval spiracle.

Metanotum glabrous except for row of 10 setae on posterior margin. Elytra and wings hyaline, extending to anterior margin of abdominal segment 7. Posterior margins of lateral tubercles each bearing 3 setae. Abdominal terga 1-6 each with a marginal row of 16-18 setae. Tergite 7 short, bluntly V-shaped with 12-14 setae along posterior margin. Tergite 8 short, concealed beneath 7; 8 marginal setae. Tergite 9 tapered, visible from above; ending in a sclerotized spine; 10 marginal setae. Sterna glabrous, shining. Legs with 3 setae near apex of each femur; hind femora extending to abdominal segment 6; tarsi directed posterad. Spiracles present on abdominal segments 1-8; gradually decreasing in diameter posteriorly; annular, peritremes raised above general level of cuticle; heavily sclerotized.

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